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**BOSTON SOCIETY**  
**OF**  
**CIVIL ENGINEERS**



**DECEMBER - 1933**

**VOLUME XX**

**NUMBER 10**

# BOSTON SOCIETY OF CIVIL ENGINEERS

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# COMING MEETINGS

*SOCIETY—WEDNESDAY, JANUARY 24, 1934*

“The Cape Cod Canal and New High Level Bridges,”  
by Lieut. Peter T. Goerz, U. S. A., District Engineer’s  
Office, Rivers and Harbors

Place of meeting to be announced later

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*DESIGNERS SECTION—WEDNESDAY, JANUARY 10*

6.00 P.M. Society Rooms, 715 Tremont Temple, Boston

“A Method for Analyzing Stresses in Building Frames  
due to Lateral Forces,” by Dr. John B. Wilbur,  
Instructor in Civil Engineering, Massachusetts Insti-  
tute of Technology

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# JOURNAL OF THE BOSTON SOCIETY OF CIVIL ENGINEERS

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## NEW TIDEWATER FACILITIES OF THE PORTLAND TERMINAL COMPANY AT PORTLAND, MAINE

BY ASA H. MORRILL \*

(Presented at a meeting of the Boston Society of Civil Engineers, October 18, 1933)

THE Portland Terminal Company, a subsidiary of the Maine Central Railroad Company, is the proprietor of all steam railroad property in the adjoining cities of Portland, South Portland and Westbrook, with the exception of that owned by the Canadian National Railway.

The Terminal Company provides terminal, passenger, freight and wharf facilities and service for the Boston & Maine and Maine Central Railroads, each road paying its proportion of the fixed and operating charges on the basis of use. The tidewater facilities, with which this paper deals chiefly, provide for the transshipment of incoming water-borne traffic, consisting chiefly of pulp-wood, baled pulp, China clay, coal, lumber and sulphur destined locally to the paper mills and other industries of Maine, New Hampshire and Vermont and to points west (at present as far as Wisconsin).

There is very little traffic moving over our wharves from cars to ships, although the Terminal Company is fully equipped to handle any traffic offered.

### DESCRIPTION OF FACILITIES

The water facilities of the Terminal are located about three miles from the harbor entrance on both shores of an estuary known as Fore River, and are approached through a broad channel with 30 feet of water at mean low tide. Fig. 1 shows the present wharves after com-

\* Assistant Chief Engineer, Boston & Maine Railroad and Maine Central Railroad, Portland, Maine.



pletion of the construction described in this article. Wharf No. 1 is located just below the bridge connecting the cities of Portland and South Portland. The L. C. L. (less carload) freight terminal is adjacent to Wharf No. 1. Ships for the other three wharves pass through a 100-foot draw opening in the bridge. Wharf No. 2, which is above the bridge, is an old wharf and is still retained in service. Wharf No. 3 is above Wharf No. 2 on the Portland side of the river. Wharf No. 4 is located on Turners Island (so called) in the city of South Portland.

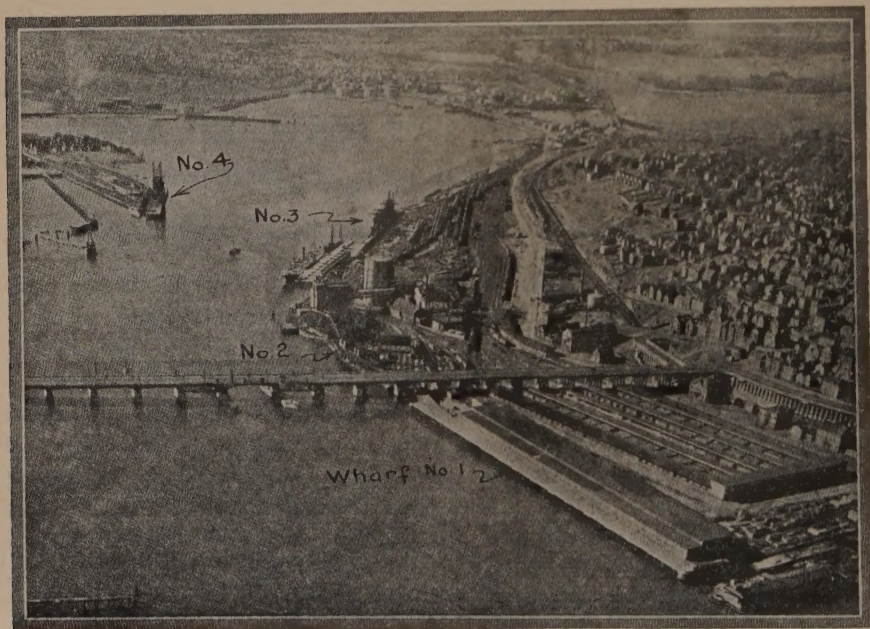


FIG. 1. — VIEW OF UPPER HARBOR, PORTLAND, MAINE

Showing location of tidewater facilities of the Portland Terminal Company

### *Old Facilities*

In order to illustrate the tendency in the development of modern wharves and cargo handling equipment, I will describe briefly the facilities which existed prior to September, 1929, and which have been replaced. Wharf No. 1 was 800 feet in length and was equipped with four McMyler coal discharging towers and a wooden sulphur storage pocket of 4,500 tons' capacity. The towers were arranged to discharge directly into cars on two tracks or into the pocket. The average dis-

charging capacity per tower was about 125 tons per hour. Wharf No. 2 was 370 feet in length and was equipped with two Mead-Morrison coal-discharging towers and an elevated cable tramway by means of which coal was loaded into cars on five tracks. This wharf is still retained in service, but is used only for discharging coal for the Portland Gas Light Company. Wharf No. 3 was 1,600 feet in length and was equipped for handling pulp-wood and China clay. A part of the equipment consisted of four wood-handling towers, by which wood was loaded into buckets and hoisted and dumped through chutes into cars on two tracks.

In September, 1929, Wharf No. 1, including the four coal discharging towers, the sulphur pocket containing 2,500 tons of sulphur and twelve steel coal cars, was totally destroyed by a fire, which was the result of oil on the water. The 8,500-ton collier "Plymouth," which was lying in the berth, was severely damaged. The heat developed was so intense that where burning sulphur came in contact with track rails the rails were melted.

In view of this disaster and the limited facilities remaining for discharging coal and sulphur, and the changing traffic through the port, it was decided to make a comprehensive survey, taking into account all pertinent factors, before adopting a policy of reconstruction. The firm of Fay, Spofford & Thorndike, Consulting Engineers, Boston, was retained to make such a survey and report. Their report was in the hands of the Terminal Company on November 18, 1929, and contained the following recommendations:

(1) Removal of the old Eastern Railroad bridge, which extended from South Portland to Portland across Fore River. This bridge was practically in disuse except for limited switching movements, and was an obstruction to navigation due to the limited draw opening of 60 feet.

(2) Construction of a new wharf to be known as No. 4, equipped with machinery for handling coal and sulphur, on the site of the old railroad shops and engine terminal at Turners Island, so called, in the city of South Portland.

(3) Construction of a new wharf and transit shed on the site of No. 1 wharf, for the handling and storage of baled pulp and package cargo.

(4) The extension and reconstruction of Wharf No. 3, to provide for the handling of pulp-wood, China clay, lumber and other commodities.

These recommendations were adopted, the work authorized on January 13, 1930, and the preparation of plans and other preliminary work were at once undertaken. The conventional design for pile and timber structures has been adhered to.

It was realized that, in competition with other ports, we must



provide the best equipment obtainable for the economical handling of cargo and the prompt dispatch of ships. To this end our management was liberal in providing such equipment.

### *Sub-surface Conditions*

From our own sad experience and that of others, the treacherous character of the river bottom was known, and wash borings were made over the sites of the proposed structures and test piles driven where possible. The sub-surface conditions on the site of Wharf No. 1 were

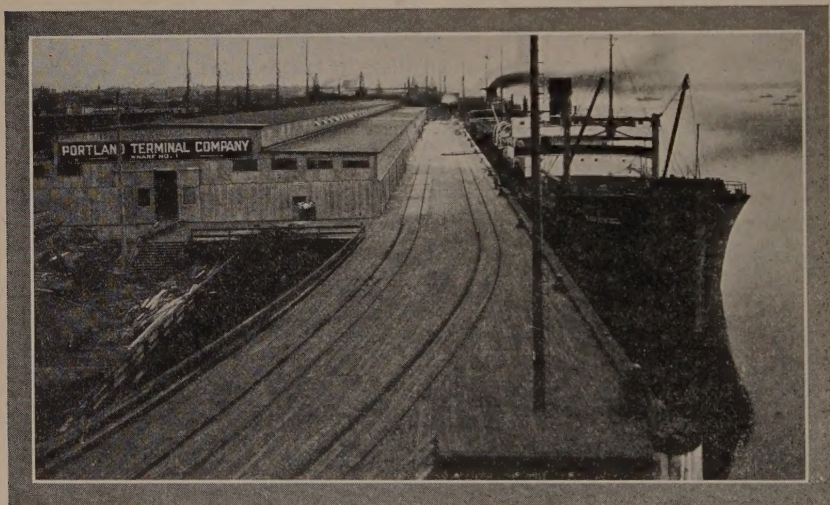


FIG. 2. — WHARF NO. 1 AND TRANSIT SHED

found to be excellent, hard packed sand being found at Elevation 35 over practically the entire area. Conditions on the site of Wharf No. 3 were not as good, as suitable bottom was not found above Elevation —60. Wash borings made on the site of Wharf No. 4 indicated soft bottom for a considerable depth, but from like conditions and tests made at the Maine State Pier it was thought that friction piles 85 feet in length would be good for a load of 8 tons on this site. About half the required piles, ranging in length from 65 to 85 feet, were ordered and the work commenced.



### *Material and Quantities*

All material for the work was furnished by the Terminal Company, and contract for labor was awarded the Merritt, Chapman & Scott Corporation of New York. The quantities involved were as follows:

Pulling 6,000 old piles; driving 8,000 new piles; placing 2,400,000 feet of timber; dredging 320,000 cubic yards; removing 2,000 cubic yards of concrete in center pier of railroad bridge. One-half the piling used in the three structures was of Douglas fir and the other half of long leaf southern pine, all piling up to 85 feet in length being of fir. All bracing was of long leaf pine; caps, stringers and ties of fir; deck plank of southern pine treated by Z. M. A. (zinc meta-arsenite) process.

### WHARF NO. 1 AND TRANSIT SHED

Work on Wharf No. 1 was commenced in March, and the work was fully completed and put into operation on October 1, 1930. This wharf has a water frontage of 1,000 feet, with 30 feet of water in the berth at mean low tide, the average tidal range being 10 feet. The wharf apron is 40 feet in width and carries two tracks, the center of the first track being 12 feet back from the face of the wharf, and the second, 31 feet. This arrangement of tracks permits the operation of a track crane on the first track to handle cargo direct from ship to cars on the second track. Ships with cargo boom of reasonable length may load direct to cars on either track. Fig. 2 shows the general arrangement of wharf, berthing space, railroad tracks and transit shed.

Water lines for supplying ships with fresh water have been run to the face of the wharf, each line being on a separate meter. A telephone line has been run under the wharf, with suitable outlets, so that usually before an incoming ship is made fast a telephone has been installed in the captain's quarters.

The transit shed, located partly on this wharf and partly on solid fill, was furnished by the Blaw-Knox Company, and is 792 feet in length by 125 feet in width, and has storage capacity for 24,000 tons of pulp, leaving 25 per cent of the floor area available for trucking. The shed is equipped with automatic sprinklers and six hydrants. It is brilliantly illuminated inside and out by 132 holophane lights and two flood lights on 80-foot masts. That part of the shed on solid fill has a concrete floor, and that on the wharf a 1 $\frac{1}{8}$ -inch maple floor laid over 3-inch plank, the wharf section being designed for a loading of 600 pounds per square

foot. Fig. 3 shows the interior of transit shed and electric tractors and trailers for handling general cargo.

The floor of shed is four feet above track level, and tracks have been planked over so that, if desired, freight may be delivered to teams or trucks from doors on this side of the building. Ramps have been provided at each end of the level, so that, if desired, trucks can be brought into the shed. On the land side of the shed two loading out tracks of 17 cars' capacity each have been provided.



FIG. 3. — INTERIOR OF TRANSIT SHED (WHARF NO. 1)

Showing electric tractors and trailers for handling general cargo

### *Cargo Handling Equipment*

Careful consideration has been given in selecting cargo handling equipment for all of these wharves. The conditions to be met in the handling and stowing of baled pulp have given us serious concern. This commodity is received in bales weighing from 350 to 600 pounds each. A ship may contain twenty or more lots, with portions of each lot stowed in different sections of the hold; 10 per cent of each lot must be set aside for sampling; it must be weighed on beam scales, and, until



recently, labor agreements prevented a sling load of more than two bales, but this has now been changed so that a greatly increased dispatch has been obtained. Our problem is to get it into piles about 14 feet high as fast as it is taken out of the ship, and for this purpose we have developed a self-propelled electrically operated boom crane which will pile at least four bales per minute (Fig. 4).

Previous to the construction of this wharf the maximum rate of discharge of baled pulp at Portland was about 100 tons per hour. We



FIG. 4. — STACKING BALED PULP IN TRANSIT SHED WITH CRANE

desired to raise this to at least 150 tons per hour, and one day recently we actually discharged from a ship 1,947 tons (approximately 10,000 bales) in eight hours. Five hatches were worked and the sling load was three bales. This meant that 21 bales per minute were landed on the wharf, and that an average of 1.4 hoists per minute per hatch was maintained for eight hours.

For stowing in shed and loading out we have provided a fleet of "chisel trucks," built by the Baker-Raulang Company of Cleveland. These trucks are a modified lift truck and will pick up from the floor or from a pile any number of bales up to four. The truck moves from



FIG. 5. — BATTERY OF ELECTRIC CHISEL TRUCKS



FIG. 6. — PILING SEVEN BALES HIGH WITH CHISEL TRUCK



pile to car under its own power, and while it is possible for an expert operator to perform this operation alone, we have found that the work is speeded up by a little manual assistance both at the pile and in the car. By the use of these trucks the cost of loading is materially reduced. Figs. 5, 6 and 7 show chisel trucks and method of operation.

For charging these trucks, which are equipped with exide ironclad batteries, we have provided equipment furnished by the Hertner Elec-



FIG. 7.—CHISEL TRUCK EQUIPPED WITH DUMP BUCKET FOR HANDLING CHINA CLAY (WHARF No. 1)

tric Company to charge twenty units. This plant is entirely automatic. As each battery is charged the current is automatically off, and when all batteries are charged the generator will cease to operate.

### *Office Building*

Adjacent to the transit shed we have erected an office building to house the superintendent of wharves, shed foreman, United States Customs and stevedores. Included in this building is a fully equipped first-aid room, and heated rest rooms and toilets for longshoremen.

## WHARF No. 4

Wharf No. 4 is 610 feet in length, has 30 feet of water in the berth at mean low tide, and is designed for the handling of coal and sulphur. It is noteworthy for its rugged construction and the extreme length of piling used. The pile bents supporting the coal towers are 3 feet 4 inches

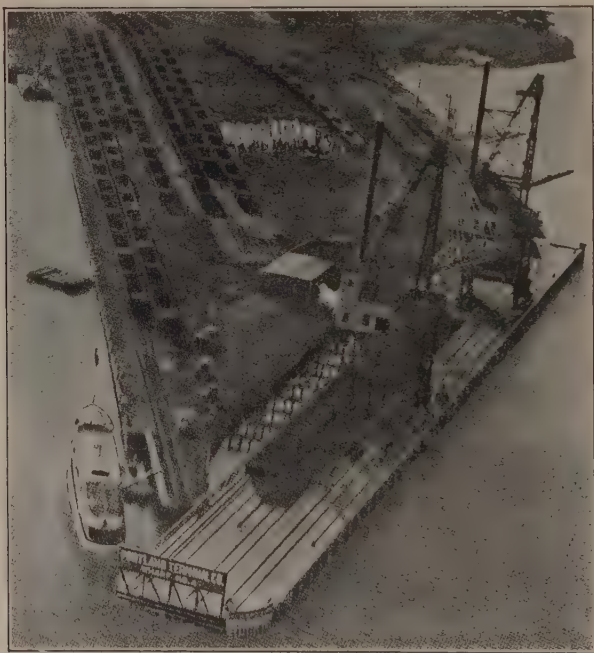


FIG. 8. — WHARF No. 4

Showing steam-operated "diggers" and railroad service yard

on centers and those supporting tracks 6 feet 8 inches. The length of piles ranges from 100 feet to 125 feet. As previously stated, it was thought that 85-foot piles would suffice, these being as long as any previously used in Portland Harbor. Driving was commenced early in April, when, much to our disappointment, the first stick was driven to grade by twelve blows of the hammer, and was going at the rate of six inches per blow when driven to grade. In the hope that the driving of



additional piles would stiffen up the bottom to give increased frictional resistance, driving was continued until 150 piles were in place. The last pile went down as easily as the first, and driving was suspended. Tests were then made by loading a single pile and a group of four piles. These tests showed that the 85-foot piles could not be depended upon to safely support a load much over eight tons. It was, therefore, decided to remove the piles already driven and use piles ranging in length from 100 to 110 feet. Fortunately we were able to obtain 300 long piles from the Erie Railroad, and these were loaded on cars at Weehawken, New Jersey, and shipped to Portland. A section of wharf 100 feet in length was completed with these piles, and the erection of the diggers proceeded with little delay. The remainder of the long piling was obtained from the Pacific coast with such promptness that the work was completed and put into service October 1, as scheduled.

### *Equipment*

The equipment on this wharf consists of two steam-operated Mead-Morrison diggers of a combined maximum capacity of 1,200 tons per hour, or an average hourly capacity of 500 tons "through the ship." The buckets are of three tons' capacity and make three and one-half trips or more per minute. The towers load on to three tracks, and 30 cars can be loaded with one "set up." A Manierre loader is provided for handling sulphur from the towers into box cars. Adjacent to this wharf is a service yard, with a capacity of 160 cars.

The performance of the equipment on this wharf has fully met our expectations. The time required for discharging an 8,500-ton cargo is about fifteen hours. On one occasion 750 tons of sulphur were discharged and loaded into box cars in three and one-half hours with a crew of six men. Fig. 8 shows Wharf No. 4, "diggers" and railroad service yard.

### WHARF No. 3

Wharf No. 3 has a water frontage of 1,500 feet, with 30 feet of water in the berth at mean low tide. This wharf is designed for the handling of pulp-wood, China clay, timber or other commodities. It is divided into two sections, each section being served by its own set of tracks. The easterly section is 1,000 feet in length, is served by four tracks and has a car-level platform 20 feet in width. The westerly section is 500 feet in length, is served by three tracks and has a car-level

platform 26 feet in width. Fig. 9 shows Wharf No. 3 and service yard.

The old wharves on this site faced on the harbor line, and the slopes under them were so steep that proper depth of water in the berth could not be maintained without endangering the safety of the structure. Application was made to the Harbor Commission and the United States War Department to change this line, carrying it out nearer the channel. The line was finally re-established as requested, the maximum change being 92 feet. The piling in this wharf ranges from 50 feet to 110 feet in length.



FIG. 9.—VIEW OF WHARF NO. 3 AND SERVICE YARD

### *Equipment and Operation*

The easterly section of this wharf is equipped with four 20-ton electrically operated gantry cranes spanning the platform and having a run of 950 feet. These cranes are equipped with 60-foot booms; have a hoisting speed of 300 to 400 feet per minute; a rotating speed of three revolutions per minute, and a maximum traveling speed of 150 feet per minute. Car haulers are provided to place cars under the cranes. In discharging pulp-wood it is piled into iron racks of three-quarters of a cord capacity, hoisted by a chain sling and deposited in open top cars on any of the four tracks. The average combined discharging capacity



of the four cranes is about 160 cords per hour, as against a maximum of 110 cords per hour with the discarded plant. Fig. 10 shows cross section of easterly section of wharf, gantry crane and railroad tracks. Fig. 11 shows one of the cranes in operation.

The westerly section of this wharf, which is used for discharging China clay, is equipped with 45-foot Burton masts located 10 feet back from the face of the wharf. Clay is handled out of ships in hand-loaded buckets and dumped into steel hoppers on the wharf platform. From these hoppers it is taken into box cars in self-dumping buckets attached

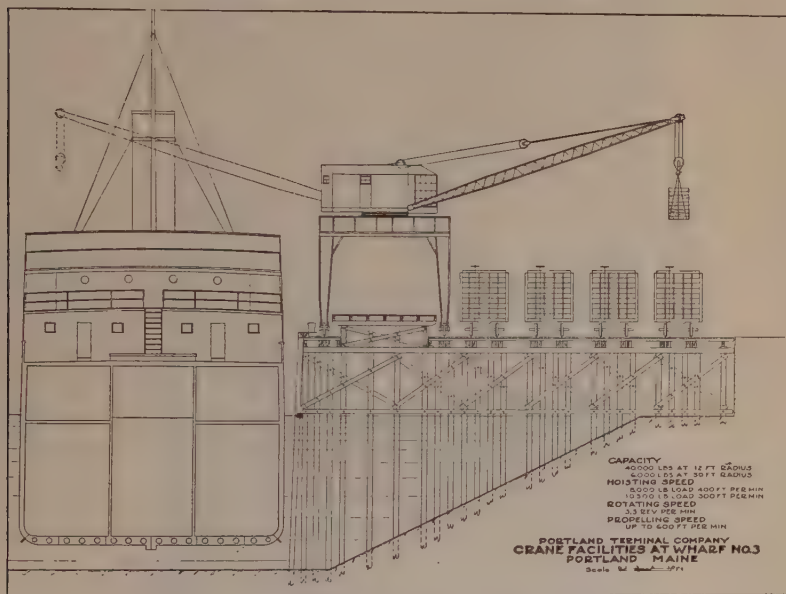


FIG. 10. — CROSS SECTION OF EASTERLY SECTION, WHARF NO. 3

to lift trucks and dumped in place without further trimming. In operation two deck winches are required. The line is run from one winch through a block at the head of the boom to the bucket. A line from the second winch is rove through a block at the head of the Burton mast and from thence to the bucket. The bucket is lifted from the hold by the first winch and is then pulled over under the Burton block by the second winch, the first winch slackening off as this move is made. The advantage of this arrangement lies in the fact that the bucket always comes to rest in a fixed spot, irrespective of any movement of the ship. This is very desirable when dumping into a barrow or hopper.

## RIGBY YARD

The Terminal Company has at Rigby, two miles from Portland, an extensive classification yard constructed ten years ago. The longest tracks in this yard have a capacity of 70 cars, which was anticipated would hold the longest train which would ever be run. Trains of 120



FIG. 11. — GANTRY CRANE IN OPERATION

to 140 cars are now operated daily. The normal daily movement through the yard averages 3,000 cars.

## L. C. L. FREIGHT HOUSE

The Terminal Company also has in the business district of Portland an extensive house for the handling and transfer of L. C. L. freight; the amount of freight handled daily in normal times averaged about



800 tons. This house consists of a head house 320 by 40 feet for the handling of inward freight, and two wings about 650 by 22 feet for outward freight. It is further provided with three island platforms 17 feet in width. All platforms are covered. It is served by 16 tracks of a combined capacity of 230 cars. Several years ago this house was equipped with five electric tractors and 400 four-wheel trailers at a cost of about \$50,000. The provision of this equipment materially reduced the cost of handling.

#### COST OF IMPROVEMENTS

The total cost of these new tidewater facilities (Wharves Nos. 1, 3 and 4) amounted to nearly \$2,000,000, of which about \$370,000 was expended for machinery and equipment.

#### Discussion

JOHN AYER:\* In the summer of 1929 a small section of a wharf of the Portland Terminal Company failed, and because of possible danger to the remaining portion of the wharf our firm was called in to determine, if possible, the cause of the failure of the wharf, and to recommend methods for reconstruction, not only of the failed portion but of the remaining wharf, if repairs were found necessary. During our studies of this part of the Terminal Company's water-front property a disastrous fire occurred at Wharf No. 1, the coal-handling plant. Immediately after the fire we were asked by the Terminal Company to make an investigation of all the water-front property of the Terminal, and to prepare a report covering the advantageous development of the water-front properties as a whole, with particular reference to the new construction required for handling present and probable future business. We were also asked to investigate the most modern methods of handling such commodities as wood-pulp and China clay, both of which furnish important business for the Terminal Company.

Our report on the development of these properties was completed late in November, 1929, and on the handling of wood-pulp and China clay early in 1930, after a study of methods in use at all Atlantic ports. Based on our recommendations Mr. Morrill, chief engineer for the Terminal Company, laid out and designed, in consultation with our firm, the structures which he has described. Our report covering the handling of pulp-wood, and recommending methods to use at Portland,

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\* Member of the firm of Fay, Spofford & Thorndike, Consulting Engineers, Boston, Mass.

was substantially adopted, but Mr. Morrill has gone a step farther than we recommended, in the design and construction of electric piling machines which have worked out so successfully. We consulted with Mr. Morrill frequently during the design, and acted in a supervisory capacity during the construction of the various terminals.

The foundation conditions along the entire water-front of Portland Harbor are the same with but few exceptions — medium to soft clay extending down nearly to rock, which is at such depth that it cannot be used for supporting foundations. In our work in connection with the Maine State Pier at Portland about ten years before, we made extensive tests in bearing power of piles in this soft clay, and determined, to our own satisfaction then, that it was not economical to lag piles in order to get a greater bearing power; rather, that we should use longer piles, as their cost would be less. In determining lengths of piles for Wharf No. 4 in South Portland, we felt that a penetration of forty feet in the clay would give us a bearing power of ten tons or more, as we found under nearly similar conditions at the State Pier. But, as Mr. Morrill has stated, the resistance of the South Portland clay was materially less than that of the clay at the State Pier, which so far as we could determine from the various borings was almost identical. For this reason it was necessary to order longer piles, which, in some cases, were nearly 130 feet. These piles were fir from the Pacific coast, and the diameters of the tops were such that it was often necessary to trim them down so that they could be placed in the gins of the pile drivers. In some cases the piles were so long that even with the soft bottom they would not penetrate into the bottom a sufficient distance to come under the hammer. In such cases either a shorter pile was used to punch a hole a sufficient depth to allow the longer pile to penetrate to a depth such that it could be hit with the hammer, or the pile pulled down to such depth that its butt would come under the hammer. The piles as driven carry two coal towers, and Mr. Morrill has recently told me that so far as could be determined from measurements there has been no appreciable settlement of the piles under the heavy loading of the moving towers.

A portion of the pier shed at Wharf No. 1 is built over water on piles, and the remainder on fill. This fill is held in place by granite and concrete retaining walls, and consists of gravel obtained from a bank near the Union Station. This gravel was placed in comparatively thin layers, watered and rolled, and the concrete floor supported directly on it. So far as we have any record there has been no settlement and

no appreciable cracks in the floor slab. The floor slab was placed in panels, but even here the joints have remained at the same elevation, and but little wearing has taken place due to trucking over them.

At Wharf No. 3, in the vicinity where the failure of the wharf had occurred, the slope of the existing bank beneath the old wharf was extremely steep, in some cases as much as one-half horizontal to one vertical. In order to provide a slope which we felt would be stable, we advised dumping of gravel in front of these steep slopes and somewhat back of the face of the new wharf, to prevent further slides or subsidence of material beneath the old wharf. Since the construction of the new wharf there has been no appreciable movement of the slopes.

CHARLES H. PRIEST:\* The Portland Terminal Company, in addition to its own intraterminal business, serves the Maine Central and Boston & Maine Railroads. The Maine Central has its own through lines from Portland to Vanceboro, connecting with the Canadian Pacific and Canadian National at that point; between Portland and Beecher Falls, Vermont, connecting with the Canadian National; between Portland and St. Johnsbury, connecting with the Canadian Pacific and St. Johnsbury & Lake Champlain Railroads; also connecting with the Bangor & Aroostook Railroad at Northern Maine Junction; also at Foxcroft. The Boston & Maine has its through lines between Portland and Mechanicville and Rotterdam Junction, New York, connecting with the Delaware & Hudson and New York Central Railroads; between Portland and Boston and its northern routes, connecting with the Canadian National, Canadian Pacific, Central Vermont and Rutland Railroads. The Canadian National has its own terminal at Portland, and the Portland Terminal Company has joint switching arrangements with that road—about four-fifths of a mile along the water-front. In the matter of freight rates to Central Freight Association territory, on our principal commodities Portland is on the same basis as Baltimore. After careful review of the situation we decided to establish water terminals and facilities for handling baled pulp and any other commodity available, and Mr. Morrill has outlined to you the results of our study and the facilities provided.

We gave much thought to the question of equipment for handling cargo; visited the principal terminals along the Atlantic seaboard, and decided that the Mystic Terminals at Boston offered the most practicable plan of operation, in their use of electric chisel trucks, lift trucks,

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\* Manager of Marine Terminals, Portland Terminal Company, Portland, Maine.



skids, dump buckets, etc. Using their method of operation as a guide we proceeded to develop our present material handling equipment, with the addition of electric pilers and some special equipment which are necessary at Portland.

### *Wharf No. 1*

The harbor approach to this wharf is very favorable, and steamers are able to move to and from the dock without towboat service. The wharf apron being unusually wide, together with large doorways on the face of the shed, makes possible an efficient operation. With electric lights along the entire face of the shed, and flood lights illuminating the face of wharf and the steamship hatches, as well as having the shed fully lighted inside, good opportunity is obtained for night work. The wharf is well adapted to the use of mechanical lumber carriers, and with the space available adjacent to the wharf we are able to handle this material efficiently. It is particularly well located for future expansion. There is space available between the present shed and the freight transfer for an additional shed — with advantages for quick and short distance handling from the transit shed to storage, and to and from railroad L. C. L. freight transfer. The Terminal Company also owns State Street Wharf, with slip at the east end of Wharf No. 1, with sufficient ground space for an ell from the present shed, where general cargo of any nature could be handled — both for rail and truck service.

There are many features in connection with the handling of bale pulp or other general cargo other than the location of a wharf, its design or equipment. The question of the customs and operating conditions which have developed at a port is an important one. The various ports along the seaboard have their local customs, which have grown a great deal like "Topsy," and these customs often supplement the agreements and sometimes seriously interfere with efficient methods of operation. For example, in the case of baled pulp; after it is handled to the end of ship's tackle it is trucked to a designated point within the shed and dropped one bale high, after which the Terminal Company has to pile it with electric pilers — three, four or five high, as desired for the chisel trucks to move away to cars or storage. At most other ports the pulp is piled by the contracting stevedore, man high, usually three bales high, inside the shed for the operators of the pier to take away with their chisel trucks, if they operate with that system, so that at Portland, in order to overcome the handicap in this particular case, additional equipment is provided. We find that the steamship people, as well as im-

porters and others, are frankly expressing their approval of our facilities for handling all cargo.

In the matter of production, the facilities afford an opportunity for handling cargo in almost any way desired, — the stevedore may use rope or chain slings, nets, hooks or any mechanical device. We frequently handled two ships at one time at this wharf; and have handled three, with their cargoes flowing into the shed from fourteen hatches. It is at such a time as this that all parts of the operation must "click" in harmony, otherwise immediate congestion results.

The shed was designed and equipped primarily for the pulp trade, and it was estimated that we would handle about 100,000 tons a year. Last year we handled about 80,000 tons, and this year we shall probably handle about 125,000 tons. In addition to this, we handle some general cargo, cotton-seed meal, lumber, etc.

### *Wharf No. 3*

This is an open wharf with a raised platform the entire length. The 1,000-foot section, equipped with four electric cranes and four tracks, and the second section, equipped with Burton masts and three tracks, also has a roof for protection in handling clay. At this wharf we are equipped to handle lumber, ties, granite, small boats to and from cars, and various kinds of bulk cargo. The electric cranes are equipped to use diggers, so that it is entirely practical for us to handle sulphur, domestic clay, fertilizer or like commodities at this wharf; in fact, we handle scrap material from cars to boats with a one and one-fifth-ton clam shell bucket, which we have provided with teeth, and which we find does excellent work in handling small scrap. The Burton mast provided at the west end of wharf tends to speed up the operation, and the changes that we have made in these facilities for handling clay, together with some changes made by the stevedores, have raised the production from six or seven hundred tons per eight-hour day to about one thousand tons.

This wharf being closely adjacent to freight yards, formerly used as classification, receiving and departure yards, has an advantage rather unusual. We also have about five acres of open space adjacent to this wharf available for storage, and with a proposed driveway, which can be provided, gives us an opportunity for such expansion as may be found necessary in the future.

*Wharf No. 4*

Our facilities at this wharf, where coal, sulphur, domestic clay, fertilizer, etc., is handled, have proved to be very satisfactory. The wharf is well designed and located, and with the track facilities provided gives an excellent opportunity to provide fast and satisfactory service. During the last year we made a slight addition to our hopper equipment by installing screens, making it possible to screen hard coal at the time it is being discharged, which enabled us to attract a considerable amount of Canadian coal through the port. We have space for such storage facilities as may be required for some time by making use of conveyors. There is also an excellent opportunity to provide for loading directly from storage to cars or trucks.



## AN ANALYSIS OF THE STORM OF NOVEMBER, 1927, BY THE RATIONAL METHOD

BY CEDRIC H. MACDOUGALL \*

(Presented at a meeting of the Boston Society of Civil Engineers, November 19, 1930)

### INTRODUCTION

ALTHOUGH a number of severe storms have occurred in the New England States on a par with the storm of November, 1927, they were before the days of accurate stream flow and precipitation measurement. Consequently, it was thought that a thorough analysis of the 1927 flood by the rational method would lead to a more thorough knowledge of the relation which exists between rainfall and flood flow on certain streams where the floods were the most severe. Such information would make possible the prediction of floods based upon rainfall probabilities.

For this purpose a rational method has been developed and applied to the following streams, and the results are then used to predict probable floods on the same streams:

- White River at White River Junction, Vermont.
- Winooski River at Essex Junction, Vermont.
- Winooski River at Montpelier, Vermont.
- Mad River at Middlesex Gorge, Vermont.
- Dog River at Northfield, Vermont.
- Lamoille River at Fairfax Falls, Vermont.
- Lamoille River at Johnson, Vermont.
- Missisquoi River at Sheldon Springs, Vermont.
- Missisquoi River at Richford, Vermont.
- Passumpsic River at its mouth (Vermont).

No description of the storm is necessary here beyond a reference to the similarity in the form of the mass curves of rainfall taken at a number of recording stations. This is even more apparent when the records are plotted on a percentage basis, as their maximum slopes are practically parallel (Fig. 1). As there was only one continuous record in northern Vermont, which was taken at Northfield, it was

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\* Research Associate, Department of Civil and Sanitary Engineering, Massachusetts Institute of Technology.

necessary to pattern the rainfall mass diagrams for all the drainage areas being considered after the Northfield record. This is justified by the uniformity of the recorded rainfalls. Intensities found in this manner were used in deriving the resulting flood hydrographs.

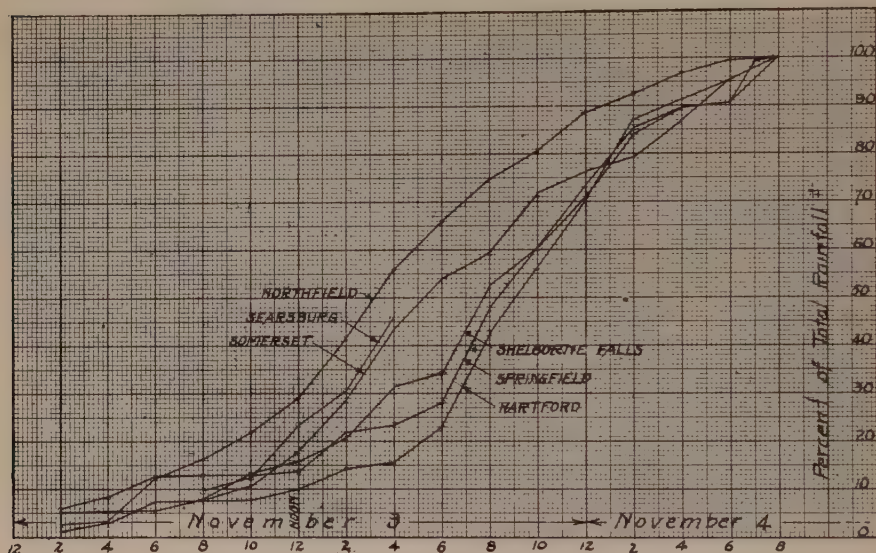


FIG. 1. — PERCENTAGE MASS DIAGRAMS OF RAINFALL

TABLE 1. — MEAN STORM RAINFALLS AND INTENSITIES

| WATERSHED      | Point             | Total<br>(Inches) | RAINFALL RATES IN INCHES PER HOUR |      |      |     |      |            |     |  |
|----------------|-------------------|-------------------|-----------------------------------|------|------|-----|------|------------|-----|--|
|                |                   |                   | November 3                        |      |      |     |      | November 4 |     |  |
|                |                   |                   | 12-4                              | 4-12 | 12-4 | 4-8 | 8-12 | 12-4       | 4-8 |  |
| White . . .    | White River Jct.  | 8.35              | .08                               | .26  | .56  | .40 | .29  | .17        | .06 |  |
| Winooski . . . | Essex Junction    | 9.10              | .09                               | .28  | .61  | .43 | .32  | .18        | .07 |  |
| Winooski . . . | Montpelier . .    | 9.50              | .10                               | .30  | .64  | .43 | .33  | .19        | .07 |  |
| Mad . . . . .  | Middlesex . . .   | 9.30              | .09                               | .29  | .63  | .44 | .33  | .19        | .07 |  |
| Dog . . . . .  | Northfield . . .  | 9.30              | .09                               | .29  | .63  | .44 | .33  | .19        | .07 |  |
| Lamoille . . . | Fairfax Falls . . | 8.00              | .08                               | .25  | .54  | .38 | .28  | .16        | .06 |  |
| Lamoille . . . | Johnson . . . .   | 8.25              | .09                               | .26  | .56  | .39 | .29  | .17        | .06 |  |
| Missisquoi . . | Sheldon Springs   | 5.89              | .06                               | .18  | .40  | .28 | .21  | .12        | .04 |  |
| Missisquoi . . | Richford . . . .  | 5.68              | .06                               | .18  | .38  | .27 | .20  | .11        | .04 |  |
| Passumpsic . . | (Mouth) . . . .   | 5.66              | .06                               | .18  | .38  | .27 | .20  | .11        | .04 |  |

## DEVELOPMENT OF A RATIONAL METHOD OF FLOOD ANALYSIS

The rational method has been chiefly used in estimating the necessary capacity for storm sewers. It usually has the form  $Q = CiA$ , where  $Q$  = flood flow,  $i$  = intensity of precipitation,  $A$  = drainage area, and  $C$  = coefficient of run-off.

This equation assumes that the storm lasts at least as long as the concentration period of the watershed, the concentration period being defined as the time of travel of the water from the farthestmost part of the drainage area to the flood point. The intensity used is the greatest probable value within the concentration period.

The simple application of this formula is inadequate for watershed of any size, since a storm of great intensity will rarely last as long as the concentration period, and it is also possible for a storm of short duration to produce a higher peak flow than the highest probable storm lasting throughout the concentration period. A much more thorough analysis of the watershed is necessary beyond a simple knowledge of its area in order to reach an accurate relation between rainfall and run-off.

In order to apply the rational method to a watershed, it must be analyzed to determine —

- (1) Distribution of the area with respect to its drainage pattern.
- (2) Average rate of travel from every section to the flood point.

As to the first, it is easily understood that equal areas may have greatly different flood characteristics, due only to the difference in the stream patterns by which they are drained. Thus, a long narrow area with a pennate pattern would probably be less flashy than a fan-shaped area having a dendroid pattern. It does not seem possible to summarize this feature by one numerical term, but it can be expressed by an area distribution curve which gives the area within any particular distance of the flood point, the distance being measured along the streams which drain the area.

The second element, or the time taken by the water from the various parts to reach the flood point, is more difficult to determine, as it involves the mean velocity of flow from any point of the system to the flood point. However, assuming that it can be estimated, the area distribution curve can be converted into an area-time distribution curve. The maximum time would be the concentration period of the watershed, and any intermediate time would show the proportion of the whole



drainage area contributing to the flow at the flood point at that time after the beginning of the storm.

From such an area-time distribution curve, the theoretical flood peak can be found for any assumed intensity and duration of rainfall. For a storm lasting as long or longer than the concentration period, the theoretical maximum flood would equal the product of the intensity and the total area. If the storm ceases within the concentration period, the flood flow will be augmented until the entire area has contributed to the flood, but at the same time it will be decreased by the unproductive area in the immediate vicinity of the flood point. Accordingly, the peak will rise after the cessation of the storm until the area which ceases

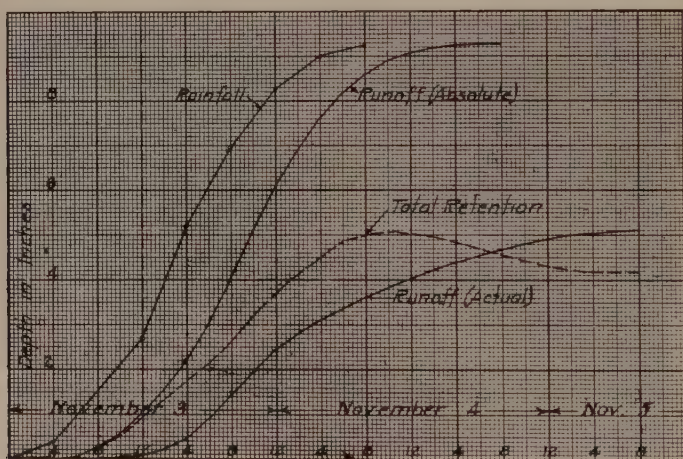


FIG. 2. — MASS DIAGRAMS OF RAINFALL, RUN-OFF AND TOTAL RETENTION, DOG RIVER WATERSHED

to contribute to the flood becomes equal to the area which continues to add its quota.

Accordingly, from the area-time distribution curve a flood hydrograph can be found for any duration of storm. As no run-off factor is considered in its determination, it may be termed the absolute flood hydrograph, and a series of absolute flood hydrographs for storms of various durations will be called the characteristic flood curves of a drainage area.

The absolute flood peak is reduced by two factors, — absorption and temporary storage between banks of the streams during the period of rising stage. These factors are well illustrated by the mass curves of rainfall and run-off for the Dog River at Northfield during the 1927

storm (Fig. 2). For some time after the rain commences there is no run-off, and one-half of an inch of rainfall is absorbed before the stream begins to rise. Then, as the discharge increases, the absolute flow is reduced by the continued absorption and by the increasing temporary storage. The latter attains the maximum when the peak of the flood is reached, but the absorption continues to increase until the end of the storm. Sufficient information is lacking to accurately separate the total retention into these two factors. But there can be no doubt that a theoretical consideration should contain two coefficients with which to reduce the absolute flow.

In this paper the coefficient of total retention, which is the product of the temporary storage and absorption coefficients, will be called the peak coefficient. It is the writer's purpose in this paper to get some idea of the value of this coefficient by applying the rational method here described to the 1927 storm.

### COMPUTATION METHODS

In applying the rational method to the 1927 storm a series of computations were necessary which will now be described in the order in which they were made.

#### (1) *Mean Elevation of Drainage Areas*

The mean drainage area elevation was computed wherever United States Geological Survey maps were available by subdividing the area into one-mile squares and taking the arithmetical mean of the elevations at each intersection. Of the streams investigated, only the White, the Mad and the Dog Rivers are completely mapped. The elevations of the remainder were taken from Professor Barrows' Vermont Flood Report.

#### (2) *Mean Storm Rainfall*

Theissen's method was used to determine the weighted mean elevation and the weighted mean rainfall on each area. The mean rainfall was then adjusted to the mean elevation of the drainage area by applying the relation shown on the elevation rainfall relation curve (Fig. 3).

#### (3) *Average Stream Velocities*

The most difficult factor to estimate is the rate of travel of any particle of water from its point of precipitation to the flood point. An attempt was made to derive this information from a study of recording gage records by observing the length of time from the beginning of a

flood until the time of peak. This would be the concentration period of the watershed if the storm had lasted at a fairly uniform rate as long as the concentration period. But such storms are rare and nothing satisfactory was learned.

Next, a study was made of the stream rating curves used by the United States Geological Survey on the streams in northern Vermont. An inspection showed that the average velocity tends to become constant at higher discharges. In most of the streams it approaches a value

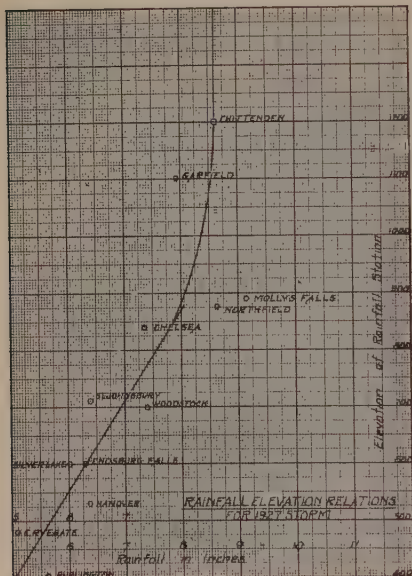


FIG. 3. — RAINFALL ELEVATION RELATIONS FOR 1927 STORM

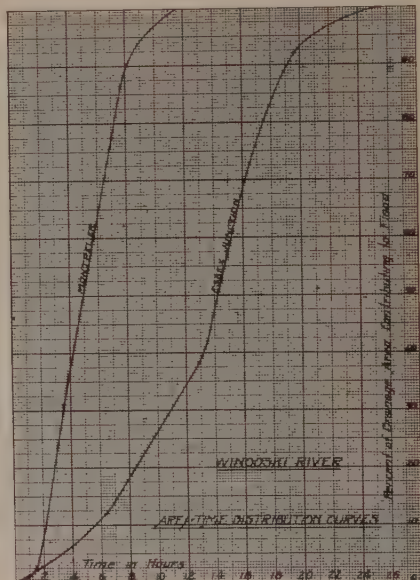


FIG. 4. — AREA-TIME DISTRIBUTION CURVES, WINOOSKI RIVER

between three and four feet per second at normal flood stages, irrespective of the size of the streams. This is probably due to the fact that erosion takes place very rapidly at velocities greater than four feet per second; and, consequently, the channel is enlarged until the velocity is reduced below this critical value. But the maximum discharges recorded on any rating curves are so much less than the flood flows of 1927 that it is not possible to extrapolate with any assurance of accuracy.

Finally, it was decided to compute the velocities of stream flow by Kutter's formula, using average slopes of the rivers taken from topographic maps. In order to get an idea of the proper roughness factors



to use, a value was computed for high discharges taken from the United States Geological Survey rating curves. The average of nine rating sections gives a value for  $n$  equal to .05.

As gaging stations are established in quiet, regular reaches, an average friction factor for the whole stream would be higher than for the gaging sections. But it would also decrease as the flow increased. For the purpose of average velocity computation, a value of .05 was adopted for the lower sections of the streams, and this was increased to .09 in the headwaters.

The velocity is also dependent on the hydraulic radius, and this factor is more difficult to approximate. It normally, however, will have a maximum value at the lower end of the stream and will decrease towards the headwaters. It will vary with the discharge and therefore with the size of the drainage area. Accordingly, in the computations for average velocity a mean depth was assumed at the lower end of each stream, and this value was decreased proportionately to the decreased drainage area for calculations upstream.

The method thus outlined is very approximate, but if applied alike to all parts of the watershed it will give comparative results of value, since the time relation of the various parts of the watershed to each other is more desired than the correct velocity at any one point.

#### (4) *Area Distribution Curve*

Wherever topographic maps were available, the distribution of the drainage area with respect to the distance from the flood point was found by planimeter measurements. Starting at the flood point, distances were scaled upstream to the headwaters along every main route by which water would flow to the flood point. Then all the points at any specific distance being considered were joined by following the natural topographic divide between each pair of adjacent points. The area bounded by the connecting line is then the total area within the specified distance of the flood point, and it furnishes one point on the area distribution curve. By repeating the measurement for various distances, a smooth curve can be plotted.

#### (5) *Area-Time Distribution Curve*

The area distribution relation is easily converted into a time relation by dividing the distances by the average velocity of travel for each distance to the flood point. It is advantageous to change the area to

a percentage of total area basis, and the result is a relation showing a percentage of the total area contributing to the flood flow at any given time after the commencement of the storm (Fig. 4).

In connection with the above derivation, there arises a question as to the accuracy of applying any particular velocity to an entire section of the drainage area which is drained by a number of streams undoubtedly having different velocities. The resulting error might be considerable were these differences of appreciable amount. But on account of the tendency of streams to approach the same velocity at flood stages, and because the water usually travels the greater part of its journey by the main channel, this error is probably unimportant. However, where the tributaries vary considerably in size and slope, as is the

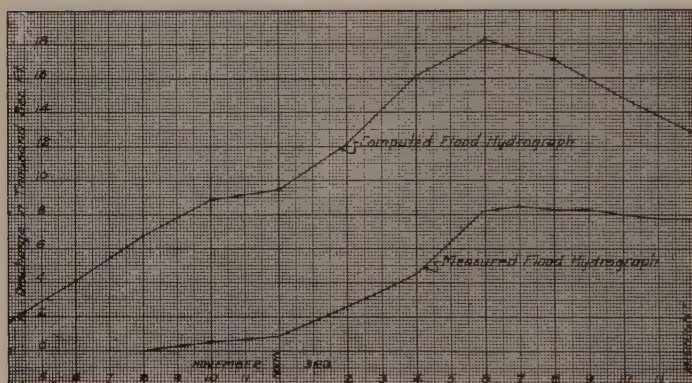


FIG. 5. — COMPUTED AND MEASURED FLOOD HYDROGRAPHS, DOG RIVER AT NORTHFIELD, VERMONT

case with the White River, it is advisable to construct an area-time relation for each tributary, and then by making use of the velocity in the main channel to compile a relation for the entire watershed.

#### (6) *Absolute Flood Hydrograph*

For a storm of a single intensity and duration, the resulting absolute hydrograph could easily be taken from the characteristic flood curves for the area, but with a storm of varying intensity the problem is more difficult, as it is necessary to consider each change, both positive and negative, in the intensity of the rainfall as a separate problem, and finally to make an algebraic summation of the various parts to get the

hydrograph for the entire storm. This procedure was followed in deriving absolute flood hydrographs for the 1927 storm. The storm was subdivided into eight periods of uniform intensity, and a partial hydrograph was computed for each increment of intensity. Fig. 5 shows the resulting hydrograph compared with the actual hydrograph of the Dog River at Northfield.

### SUMMARY OF RESULTS

The absolute peak flows, as derived by the method just described, are as follows:

TABLE 2.—COMPARISON OF ABSOLUTE AND MEASURED PEAK FLOWS, 1927 STORM

| RIVER          | Flood Point       | Area<br>(Square<br>Miles) | ABSOLUTE PEAK |              | MEASURED PEAK |              |             |
|----------------|-------------------|---------------------------|---------------|--------------|---------------|--------------|-------------|
|                |                   |                           | Total         | Unit<br>Flow | Total         | Unit<br>Flow | Coefficient |
| White . . .    | (Mouth) . .       | 720                       | 197,800       | 275          | 145,000       | 201          | 73.3        |
| Winooski . .   | Essex Junction    | 1,020                     | 280,400       | 275          | 116,000       | 114          | 41.3        |
| Winooski . .   | Montpelier . .    | 420                       | 144,500       | 344          | 60,000        | 143          | 41.5        |
| Dog . . .      | Northfield . .    | 52                        | 18,240        | 350          | 8,000         | 154          | 43.8        |
| Mad . . .      | Middlesex . .     | 140                       | 46,430        | 331          | 23,000        | 164          | 49.5        |
| Lamoille . .   | Fairfax Falls . . | 529                       | 111,300       | 211          | 66,900        | 126          | 60.0        |
| Lamoille . .   | Johnson . .       | 291                       | 73,900        | 254          | 41,600        | 143          | 56.4        |
| Missisquoi . . | Sheldon Springs   | 806                       | 127,000       | 157          | 62,900        | 78           | 49.5        |
| Missisquoi . . | Richford . .      | 445                       | 77,000        | 173          | 45,000        | 101          | 58.3        |
| Passumpsic . . | (Mouth) . .       | 484                       | 92,400        | 191          | 56,700        | 117          | 61.5        |
| Average . .    | —                 | —                         | —             | —            | —             | —            | 53.5        |

The peak coefficient is a measure of the total natural storage at the time of peak flood flow, and it represents the reduction of the absolute peak flow by the natural storage of the watershed and by the absorption of the rainfall. It is quite different from the percentage run-off factor found in most flood flow equations.

On account of the many assumptions necessary in deriving the absolute flood hydrograph, the peak coefficients are doubtless subject to many inaccuracies. In order to make a comparison of results, the computed and measured unit flood peaks on the Winooski, Lamoille and Missisquoi Rivers have been plotted on logarithmic paper (Fig. 6). This plot shows two surprising results,—one, that the slopes of the peak flow area relations of the three rivers are almost the same;



and the other, that the computed relation and the measured relation on each river are practically parallel.

From this the following conclusions may be drawn:—

(1) That the peak flow of a watershed may be expressed by the general formula  $q = mA^n$ , where both  $m$  and  $n$  are dependent upon the flood characteristics of the watershed and upon the intensity and duration of the rainfall.

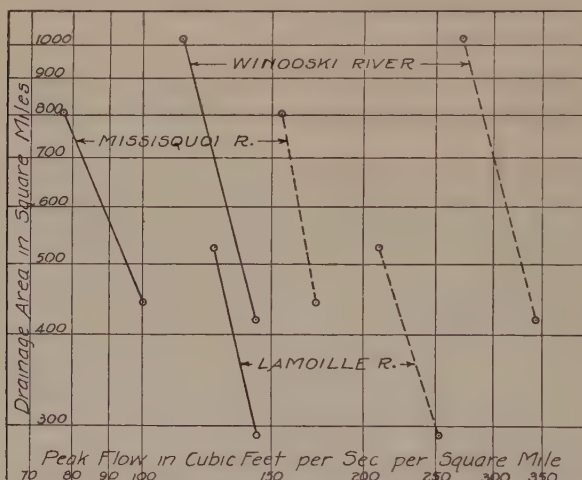


FIG. 6. — ABSOLUTE AND MEASURED FLOOD FLOWS, 1927 STORM

(2) That the assumptions made in developing the flood hydrograph by the rational method are sufficiently close to obtain a good knowledge of the exponent  $n$  of this formula.

(3) That the peak coefficients are related only to the coefficient  $m$  of the formula. Thus the actual peak flow would be  $q = PmA^n$ , where  $P$  is the peak coefficient.

The unit peak flow equations for the 1927 flood are as follows:

- (1) Winooski River:  
 $q = .42 \times 1570 A^{-.25}$  sec. ft. per sq. mi.
- (2) Lamoille River:  
 $q = .58 \times 880 A^{-.223}$  sec. ft. per sq. mi.
- (3) Missisquoi River:  
 $q = .55 \times 2400 A^{-.425}$  sec. ft. per sq. mi.

These equations are given to show the variations in the coefficients and exponents. Of chief interest is the narrow range of peak coefficient compared to the variation in  $m$  and  $n$  for the same storm on adjacent watersheds. As the latter was derived entirely by the rational method, it is only necessary to estimate the peak coefficient when computing the storm run-off for a given intensity of rainfall. The values listed in Table 2 will rarely be exceeded, since the conditions during the 1927 storm were exceptionally favorable to a high run-off.

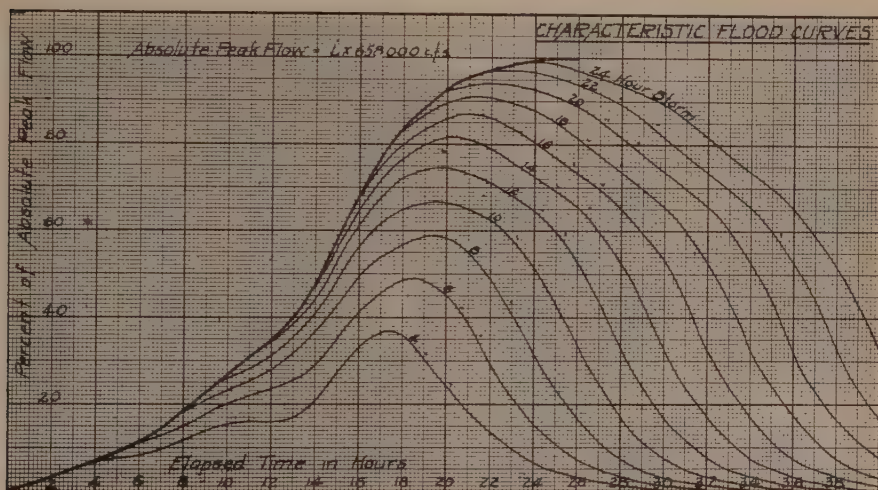


FIG. 7. — CHARACTERISTIC FLOOD CURVES, WINOOSKI RIVER AT ESSEX JUNCTION.

#### APPLICATION OF THE RATIONAL METHOD TO FLOOD PREDICTION

Using the rational method, flood predictions can be made directly from rainfall probabilities rather than from probability studies of previous floods or from flood equations in which constants must be estimated which have a high range of possible values.

Using the rainfall intensity relation which has been proposed for Boston, and assuming that it is applicable in Vermont, the fifty and one hundred year floods have been computed for the streams being considered in this paper. The rainfall equation is —

$$i = \frac{16F^{0.27}}{(t+7)^{0.7}}$$

where  $i$  = intensity in inches per hour,  $t$  = storm period in minutes, and  $F$  = storm frequency in years.

The flood characteristic curves (Fig. 7) were used to determine the maximum absolute peak for each watershed. This was done by assuming various storm periods and determining the peak flow for the corresponding intensity of precipitation. To convert these absolute peak flows into actual flows the peak coefficients found from the 1927 flood were applied. For the purpose of comparison, the probable fifty and one hundred year floods as computed by the rational method are listed in Table 3, together with the 1927 flood.

TABLE 3. — PROBABLE FLOOD FLOWS IN NORTHERN VERMONT

| RIVER            | Flood Point         | PROBABLE FLOOD PEAK |                  | 1927<br>Flood<br>Total |
|------------------|---------------------|---------------------|------------------|------------------------|
|                  |                     | 100-Year<br>Storm   | 50-Year<br>Storm |                        |
| Winooski . . .   | Essex Junction . .  | 109,000             | 88,000           | 116,000                |
| Winooski . . .   | Montpelier . . .    | 66,000              | 55,000           | 60,000                 |
| Lamoille . . .   | Fairfax Falls . . . | 69,000              | 57,000           | 66,900                 |
| Lamoille . . .   | Johnson . . .       | 47,000              | 39,000           | 41,600                 |
| Missisquoi . . . | Sheldon Springs . . | 97,000              | 82,000           | 62,900                 |
| Missisquoi . . . | Richford . . .      | 77,000              | 65,000           | 45,000                 |
| White . . . .    | (Mouth) . . . .     | 152,000             | 127,000          | 145,000                |
| Passumpsic . . . | (Mouth) . . . .     | 97,000              | 81,000           | 56,700                 |



# OF GENERAL INTEREST

## PROCEEDINGS OF THE SOCIETY

### MINUTES OF MEETINGS

#### Boston Society of Civil Engineers

NOVEMBER 15, 1933. — A regular meeting of the Boston Society of Civil Engineers was held this evening in Chipman Hall, Tremont Temple, and was called to order by the President, Arthur W. Dean, at 7.10 P.M.

This meeting was the annual Joint Meeting with the following Student Engineering Societies: Northeastern University Section of the Boston Society of Civil Engineers and Student Chapters of the American Society of Civil Engineers at Harvard University, Massachusetts Institute of Technology and Tufts College.

About 220 members and guests were present and 188 attended the buffet supper preceding it. During the supper music was furnished by representatives of the musical clubs of Northeastern University.

The President extended a welcome to these students and expressed appreciation of the co-operation of student officers and faculty members of the Society who have endeavored to make this meeting a success.

The Secretary announced the election of the following new members:

*Grade of Member:* Stanley M. Dore.

*Grade of Student:* John Franklin Wiseman.

The President stated that at the last meeting of the Society held on October 18, 1933, a vote was passed regarding the use of current income from the Permanent Fund. A similar vote is necessary at this meeting, therefore the following vote was taken:

*Voted,* That the Board of Government be authorized to use in so far as necessary

the current income from the Permanent Fund for current expenses of the Society.

The President then introduced the speaker, Mr. Walter H. Kilham, Jr., architect, who gave an interesting talk on "Radio City, Rockefeller Center, New York."

The speaker was associated with the three firms of architects on the design and construction of these buildings, and had taken many motion pictures, as well as still pictures, which were shown on the screen.

An informal question period followed the talk.

Adjourned at 9 P.M.

EVERETT N. HUTCHINS, *Secretary*.

#### Sanitary Section

DECEMBER 6, 1933. — A regular meeting of the Sanitary Section of the Boston Society of Civil Engineers was held at the rooms of the Engineering Societies, 715 Tremont Temple, with Chairman Bogren presiding.

The subject discussed was "Measurement of Sewage Flow." Mr. Karl R. Kennison, designing engineer, Metropolitan District Water Supply Commission, spoke on "The Measurement of Sewage Flow by New Type Open Nozzles." This new type of flow nozzle was developed by Mr. Kennison to measure the sewage flow from the Rutland-Holden district prior to discharge to the Worcester sewerage system. It makes possible the accurate measurement of low flows and a much wider range in flows than is practical with the standard Venturi tube.

Mr. Charles G. Richardson, sales engineer, Builders' Iron Foundry of Providence, described the large Parshall

Flume recently installed to measure the sewage flow at the Providence sewage treatment plant.

Among those who took part in the discussion which followed were Messrs. Camp, Shaw, Eddy, Fair, Haley and Dresser. There were 22 at Patten's for dinner before the meeting and 50 in attendance at the meeting.

FRANK L. FLOOD, *Clerk.*

## APPLICATIONS FOR MEMBERSHIP

[December 20, 1933]

THE By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of fifteen (15) days from the date given.

### *For Admission*

BAKER, WARREN FRANCIS, Newton Center, Mass. (Age 34, b. Dorchester, Mass.) Wentworth Institute, day school, one year (1916-17), course in carpentry and building; building course, evening school, 1930, Massachusetts Institute of Technology. Experience: 1915-16, blue printer, Stone & Webster Engineering Corporation; 1917-18, draftsman on ventilating equipment, Sturtevant Blower Works; November, 1918, to January,

1923, rodman, lines and grades for roads and bridges, construction work and surveys, Metropolitan District Commission; March, 1923, to October, 1923, transitman, lines and grades, power plant at Weymouth, for Stone & Webster Engineering Corporation; October, 1923, to August, 1926, civil engineer, and inspector on road construction and small dam for Metropolitan District Commission; August, 1926, to present time, civil engineer, on plans and estimates for highways, and from March, 1930, as structural draftsman in bridge division, Massachusetts Department of Public Works. Refers to *G. E. Harkness, A. E. Kleinert, Jr., F. H. Morris, J. H. O'Connor.*

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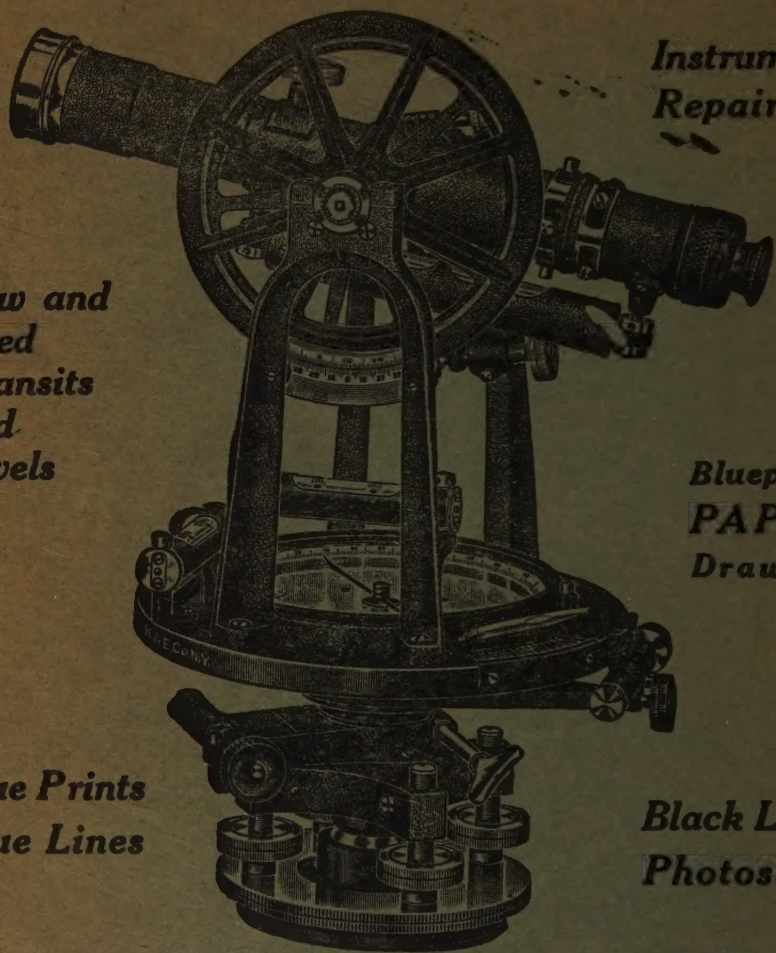
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